

Mo/Na₂TiO₂ Mixed Conducting Electrodes for the Alkali Metal Thermal to Electric Converter

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Components of the Alkali Metal Thermal to Electric Converter (AMTEC) have been studied at JPL for several years with a view to characterizing the performance parameters of the electrochemical cell as a step to understanding and improving the performance of an AMTEC device. In an AMTEC cell, as in any cell using electrodes deposited on a solid electrolyte, the electrode must allow the transport of one or more species. In the AMTEC cell, the working fluid is vapor phase alkali metal, typically sodium.

Electrode studies have typically focused on the sheet resistance in the electrode, the exchange current as measured by the interfacial impedance, and the resistance to sodium flow through the electrode and away from the interface. These parameters are typically reported as R_{sh} , the sheet resistance measured before and after an experiment, B , the temperature independent exchange current, and G , the (dimensionless) morphology factor, respectively [1,2]. In experiments at JPL, these parameters are typically measured in Sodium Exposure Test Cells (SETC) [3] as well as in power-producing AMTEC cells.

It has been shown previously that the performance of an electrode can be improved if a material which is an ionic conductor to the alkali metal is incorporated in the electrode. The performance effect of the presence of an ionic conductor in the electrode is to increase the magnitude of the exchange current and to decrease the resistance to sodium transfer through the electrode; *i.e.* increasing B and decreasing G . This effect has been previously noted with the sodium ion conductors sodium molybdate and sodium tungstate early in life for electrodes containing molybdenum and tungsten electrodes, respectively [4].

Recent work in this and other laboratories has shown that TiO₂ will react with gaseous sodium at high temperature to form Na-Ti-O compounds which are both electronically and ionically conducting [5-7]. TiO₂ powder which was exposed to low pressure sodium vapor at AMTEC operating temperatures has been identified as Na_{0.5}TiO₂ by gravimetric analysis and X-Ray Diffraction. [7]. The conductivity of the Na-Ti-O compound formed by exposing TiO₂ to sodium vapor at 600 - 850 °C was

measured, and found to be dependent on the sodium pressure as well as the temperature. As Na-Ti-O compounds are known to be electronically conducting, it was not possible in this work to separate ionic from electronic conductivity.

To test the performance of mixed conducting electrodes for AMTEC applications, electrodes were made by mixing Mo and TiO₂ (anatase) powder with an organic cement in a slurry and applying them to β'' -alumina solid electrolyte. The samples were fired in vacuum for 2 hours at 1000 °C to remove the cement and sinter the electrode, resulting in an electrode 5 μ m thick. The electrodes were then operated for several hundred hours at 750 - 850 °C in a sodium vapor atmosphere where the sodium pressure was varied from 0.01 to 5 Pa.

Current-voltage curves and electrochemical impedance spectroscopy were used to characterize the electrodes. It was found that mixed conducting electrodes showed superior performance to electrodes made from Mo alone; both exchange current and sodium transport were improved in the mixed electrode. Performance improved dramatically in the first 20 hours of operation, as the TiO₂ in the electrode reacted with Na vapor to form the Na-Ti-O compound. Over the following 1500 hours of operation, the performance of the electrode was not found to change significantly.

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